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ABSTRACT

A study evaluated the effectiveness of a series of print materials and interactive computer-guided study programs designed to lead undergraduate students to apply basic textbook reading and concept mapping strategies to the study of science and social science textbooks. Following field testing with 25 learning skills students, 50 freshman biology students enrolled at Indiana University were divided into treatment and control groups. Both groups read two 7-10 page biology textbook selections. Treatment students scheduled three weekly one-hour appointments using the computer programs, which helped students identify key concepts, write summary statements comparing and contrasting concepts, and graphically map relationships among concepts. After each lesson students answered a questionnaire on the usability of the lesson, and on completion of the last lesson, chapter examinations were given along with an open-ended questionnaire evaluating the program. One week after the chapter exam, treatment subjects read a new biology text and were given an exam on the new material. Control students were provided only with the text and completed the same examination taken by the treatment group. They also returned one week later to repeat the process with the new text. Findings showed that treatment students significantly outperformed control students for both texts in ability to link terms and map concept relationships. Questionnaire data indicated that computer instruction was viewed positively as a way to learn strategies for reading difficult material. (Two tables of data are included, and 23 references are appended.) (MM)

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The Effectiveness of Interactive Computer Assisted Modeling in Teaching Study Strategies and Concept Mapping of College Textbook Material

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Most beginning undergraduate students have the basic reading skills needed to understand a newspaper (Applebee, Langer & Mullis, 1985), but many of these students have difficulty reading and studying college textbooks. Cahalan and Farris (1986) report that 82% of all institutions of higher education and 94% of public institutions offer remedial courses to college undergraduates. The National Center for Educational Statistics reports that 25% of undergraduate students seek some form of remedial help with university-level study problems This problem of undergraduates inadequately prepared to comprehend university-level material is even greater at smaller community colleges and open admission schools. Seventy-five per cent of students at two-year and open-admissions colleges are enrolled in remedial courses ("College remedial," 1985).

Techniques for improving undergraduate reading and study skills often involve instructors modeling for students cognitive and metacognitive strategies for identifying key ideas and relating ideas to form meaningful structures. The premise of the research reported in this paper is that an interactive computer program can model and guide undergraduate students through some of the important cognitive and metacognitive processes of reading college textbook chapters in such a way that: 1) comprehension of the modeled chapters is increased and 2) students are able to transfer the processes to new, unmodeled chapters effectively.

This manuscript reports phase one results of a two-year project funded by the Fund for the Improvement of Postsecondary Education (FIPSE). This research and development project is designed to develop and evaluate the effectiveness of a series of print materials and interactive computer-guided study programs which lead undergraduate students to apply basic textbook reading strategies and concept mapping strategies to the study of science and social science textbooks. The materials and computer programs

are designed to guide and help students:

* Identify key concepts in textbook chapters,
* Compare, contrast, and connect ideas by writing linking summary statements, and
* Synthesize and graphically map relationships among key concepts.

Reading Abilities and Demands of Entering Undergraduates

Over 56% of 17-18 year olds go beyond high school to some form of post-secondary education. The percentage of students that enter colleges and universities is less clear due to differing definitions of what constitutes a college, but remains in the 40-50% range (Lisack & Shell, 1985).

Though complete data upon the reading abilities of under-graduates does not exist, National Assessment of Educational Progress (N.A.E.P.) reading test results for 17-year-olds (Applebee, Langer & Mullis, 1985) allow us to draw inferences about the reading abilities of adolescents who enter colleges and universities. N.A.E.P. results for 1984 indicate that only 39.2% of 17-year-olds demonstrated adept comprehension strategies (able to find, understand, summarize, and explain relatively complicated information). Furthermore, only 4.9% attained an advanced level of strategy use (able to extend and restructure ideas in specialized texts). With current admissions in post-secondary education close to 50% of 17-18 year-olds, one can expect a significant number of undergraduates to have difficulty comprehending relatively complicated textbook material and a majority to have difficulty restructuring and extending ideas from such specialized texts.

Several researchers have identified and characterized weaknesses that differentiate less competent readers from their more capable counterparts.

Such readers are likely to have gaps in knowledge, have an impoverished understanding of relationships among facts, and are unlikely to make the inferences required to weave the text into a coherent whole (Bransford, Stein, Nye, Franks, Auble, Merynski, & Perfetto, 1982). Less able readers tend to use a listing rather than a structure strategy because they perceive all content as equally important. (Meyer, 1984b; Meyer, Brandt & Bluth, 1980; Meyer & Rice, 1982).

Structure Awareness, Concept Mapping and Improved Reading

The results of several studies suggest that students who are aware of the structure of expository materials are able to outperform students who are not aware of text structure (McGee, 1982a; McGee, 1982b; Meyer, Brandt & Bluth, 1980; Taylor, 1980; and Taylor & Samuels, 1983). In addition, readers who are actively involved in constructing a structured representation of what they have read do better than their counterparts in recall performance (Armbruster & Anderson, 1980; Slater, 1982; Berkowitz, 1986; and Danner, 1976). Some researchers examining the effectiveness of having students graphically depict the relationships among major concepts in text (concept mapping) have found carry-over benefits to related language activities. Ruddell and Boyle (1984) found that students who used concept mapping as a pre-writing exercise were able to write longer, higher quality essays than their counterparts. Geva (1983) found students who were taught to map or flowchart their understanding of expository material not only improved in mastery of the mapped material, but also improved in general reading ability as measured by a standardized reading test.

Role of Modeling and Computers

The modeling of cognitive processes has been suggested by several researchers and educators as a method for clarifying to less able readers methods of thought while reading (Brown, 1980; Davey, 1983; Smith & Dauer,

1984). Suggested techniques usually incorporate explication of the techniques being modeled, modeling of strategies and techniques to be used, and then student practice and feedback.

An instructional format for effective computer-assisted instruction has been developed by Alessi and Trollop (1985). This format also includes 1) explication of the concepts, 2) modeling of the strategy, 3) practice and feedback, and 4) assessment and branching.

Rationale of Study

Large percentages of undergraduate students seek aid in meeting the reading demands of college. It is likely that even larger percentages are in need of such aid. Interactive computer programs may be able to help meet this need if they can effectively model and instruct students in cognitive and metacognitive reading strategies shown by existing research to be effective. This study assesses the utility and effectiveness of three interactive computer programs and associated print materials in instructing and modeling for undergraduates how to comprehend and reconceptualize scientific textbook material. In addition to formative evaluation, the programs were evaluated by comparing the immediate and delayed post-program performance on textbook chapter tests of a treatment group of 25 biology students to the performance of a matched control group of 25 biology students. Post-program questionnaires and interviews given to treatment group students assessed student evaluation of computer program effectiveness.

METHOD

Subjects

The biology textbook computer programs and associated print used in this study were field tested with the aid of 25 undergraduate students

enrolled in Learning Skills courses at Indiana University. Formative evaluations examined program clarity, usefulness, and student attitudes toward the programs. Responses from students were used to refine and debug early versions of the materials and computer programs.

After the refinements had been made, 50 second semester freshman volunteer biology students (34% male and 66% female) who received class credit for participation were divided into treatment and control groups matched on SAT verbal scores, high school rank, and university grade point average (4.0 scale).

Student averages follow below.

	N	SATV	GPA	H.S. Rank
Treatment	25	422	2.65	26.8 %
Control	25	426	2.64	27.8 %

Instruments and Materials

Textbook Passages: Both treatment and control students read two 7-10 page selections from the embryonic development chapter and the blood composition chapter of Elements of Biological Science (Keeton & McFadden, 1983). These selections and this text were selected with the aid of biologist, Dr. Albert Ruesink, as topics, text formats, and difficulty levels typical of most college level introductory biology texts.

Computer Programs: Three 30-40 minute computer programs were designed to follow biology text material dealing with embryonic development. The programs modeled for students how to
1) identify key concepts within a text, 2) write linking summary statements which compare and contrast key concepts, and 3) graphically map relationships among key concepts.

The instructional format of the programs is adapted from Alessi and Trollop's (1985) suggestions for effective CAI. They include 1)

explication of the concepts, 2) modeling of the strategy, 3) practice and feedback, and 4) assessment and branching.

- The Explication segments (generally at the beginning of each section) include a strong rationale and statement of purpose for the activity, as well as suggestions for transfer to the performance environment.

- Modeling is interspersed throughout the program and generally consists of a combination of examples and, when warranted, informative feedback.

- Students are required to Practice each step or group of steps to mastery before moving on through the program. Practice is set up in incremental steps to provide early success and reinforce each essential step in performing the strategy.

- Feedback is established as effective in CAI and the efficacy of feedback is proportional to its quality. Feedback in this program always includes knowledge of results and knowledge of correct response with feedback appropriate to the student's response--what mistake he or she is likely to make, where to look for information to self-correct, and how to avoid that error in the future.

- Answer judging always provides feedback, but sometimes includes interactive teaching if the student fails on a significant number of tries to produce a correct response. In these cases the program will Assess student performance and branch the user to remediation before returning the student to the question segment for another try.

Locus of control is offered to the students whenever possible. At least once in each program, students can opt for an "Exercises Only" or an "Explanation plus Exercises" format. This choice allows the student to determine the level of detail in which the instruction is presented. If the student who chooses "Exercises Only" has performance problems, he or she is automatically branched to the "Explanation plus Exercises" section.

The screen design follows well-established parameters for document design with appropriate modification for the screen and for the target population. For example, each screen contains a prompt at the bottom of the screen that tells the student exactly what he or she needs to do to

move through the program. Content-related direction lines are often contained in the text.

Because of the students' tendency to miss the relationships between ideas, screens are designed to interlock concepts so that related concepts are presented together on the same screen and the relationship is elaborated upon to make it more specific. Relationships are presented visually at every opportunity.

Students also are given a strong advance organizer at the beginning of each segment to tap into existing background knowledge and to set up a framework for the lesson. Each lesson section is introduced with a consistently-colored screen. When the user is in a section of his or her choosing, a small box in the upper left hand corner serves as a guide to the macrostructure.

Chapter Exams: Textbook chapter examinations were developed to test the ability of students to identify key ideas in textbook chapters, compare and contrast these ideas, and accurately depict relationships among key ideas. Parallel examinations were developed and field tested for the embryonic development chapter and the blood composition chapter.

To field test these measures, two classes (40 students) at the Indiana University Learning Skills Center read and took tests on the biology chapters. Class 1 read the embryonic text first and the blood text second; class 2 reversed the process by reading the blood text first and the embryonic text second. The chapter examinations were administered to both groups after each text was read. Mean scores (from a possible 100 points) were similar for the two tests (Embryo, 60.7; Blood, 61.9). Clear-cut scoring guidelines were developed and used to attain an inter-rater reliability correlation of $r = .95$ for the two raters scoring the tests.

Monitoring of inter-rater reliability using a 25% sample of later treatment and control subjects revealed correlations of r = .91 for the embryonic chapter test and r = .96 for the blood chapter test.

Procedures

The treatment group was notified by letter to schedule three one-hour appointments a week apart and completed one lesson each week during the last three weeks of March. After each lesson the students were asked to answer a short questionnaire on the usability of the lesson. On completion of the last lesson, the chapter examinations were given along with an open-ended questionnaire about the program and its usefulness in biology and in other courses. One week later students were asked to again return to the Learning Skills Center and to read a new biology text (blood text) and to complete a chapter examination.

The control group was also contacted by letter and asked to schedule a one-hour appointment during which they were provided with only the text (embryonic text) and asked to read it without the help of the computer and to complete the same examination that had been taken by the treatment group. They also returned one week later to repeat the process with the new text (blood text).

RESULTS

Chapter Examination Results

The chapter examinations were administered in order to determine the effectiveness of computer programs in modeling and teaching strategies for comprehending college-level textbooks. The treatment group had instruction on the computer while using the embryonic textbook chapter and was tested immediately after program completion. The blood composition chapter was read and tested upon one week later. The control group, during two sittings one week apart, read and were tested upon the two texts.

The treatment group scored significantly higher on both the embryonic and the blood chapter exams. The control group averaged 62.89 out of a possble 100 points on each chapter examination while the treatment group averaged 79.73 out of a possible 100 points on each examination. Results are displayed in Table I.

Insert Table I.

It was predicted that the computer program use would result in higher scores for the treatment group on the embryonic test since that was the text used in the computer lessons. Of greater educational significance is the result that the treatment group also significantly outperformed the control group a week later reading the blood text without aid of the computer programs, suggesting transfer of the reading strategies beyond the single chapter covered in the computer programs.

Further analysis was undertaken on scores for subsections of the chapter examinations to determine which strategies were learned most effectively. Results are displayed in Table II.

Insert Table II.

Significant differences in the treatment group's favor at the $p < .05$ level or better exist for all subsections except the identifying key concepts section of the blood composition chapter. Even in this case, the treatment group scored 92% of possible points while the control group scored 84% of possible points.

Biology class test. An unplanned indicator of program success is the fact that treatment group students outperformed control group students on items related to embryonic development on their biology class test which was not a part of this study. On questions related to embryonic development, the treatment averaged 94% correct while the control group averaged 72% correct.

Interview and Questionnaire Results

At the end of each lesson, the treatment group was asked to complete a Likert scale to ascertain student opinions of the effectiveness of the computer in developing basic skills for comprehending a biology text. The scale ranged from 5 (Strongly Agree) to 1 (Strongly Disagree). Mean results for the three computer lessons ranged from 4.20 to 4.60. Students' attitudes toward the programs were strongly positive with no significant differences in relation to sections of the programs.

The lessons were also judged to be effective by the 25 students who used the programs. Student comments during exit interviews included:

> "I hadn't thought of that before."
> "I wish they had these for my brother in high school."
> "Everything is clear about what you're supposed to do."
> "I enjoyed the lesson. It's like X151 without the extra work."
> "Oh, my god, I totally skip over drawings.
> "I wish I'd learned to study a text before I got to college."
> "Have you had success with these programs? They seem very good."

At the end of lesson III students were asked to complete an open-ended questionnaire concerning the entire program. Among the questions asked of students was: Have you ever before used the ideas presented in the computer program to:

	Yes	No
a. locate key terms?	19	5

b.	compare and contrast key terms?	13	11
c.	map relationships among key terms?	3	21

For the vast majority of students in the treatment group, graphically mapping concepts was a new and unfamiliar task. In addition, comparing and contrasting key terms was also only reported as familiar by 54% of the students.

In answer to the question: "Has your ability to understand text material improved?", twenty-one students (87.5%) answered "yes". Students answering yes were asked to expand upon the ways they thought their abilities had improved. Among the elaborations provided are:

- My biggest problem is fitting concepts together. Now I have a better feel about how to do it.
- Again, through organizations of materials. Now I have a structured method of study.
- Most of these ideas were already familiar to me, but using the lessons on the computer showed how advantageous these ideas are for learning text material.
- It takes a little more time to try and do the things you have learned (locating and comparing) but the benefits make it worth it.
- By learning to link key terms together and being better able to see the whole chapter made up of its smaller parts.

In an attempt to determine whether or not the students could see a transfer of the skills presented on the computer to other courses at the university, treatment group students were asked, "In what ways, if any, will this lesson be useful for other courses in which you are enrolled?" A sample of comments follows:

- You can apply all the concepts of the experiment to other courses with maybe the exception of math.
- Yes for sociology, etc., but not for English classes, esp.

literature.

- In almost all of my subjects, textbooks are used and set up in the same format. I hope to apply concepts learned to various areas.

- The ideas of locating key terms, comparing and contrasting, and mapping can all be used in other courses.

- Other courses where there is lots of reading involved such as my Human Development class which deals with many of the same concepts presented here.

CONCLUSIONS

With funding from F.I.P.S.E., the Learning Skills Center at Indiana University has developed a series of computer lessons to help students comprehend college level text material. Using guidelines for effective CAI and research on reading comprehension, the computer programs model study strategies and concept mapping while providing for practice and feedback.

Significant differences in examination results support the hypothesis that "how to" strategies can be taught with the use of a computer. The treatment students outperformed the control students at a statistical $p <$ from the computer programs to the blood text also at a $p < .001$ level. Significant differences in favor of the treatment group were also consistently found for both texts in abilty to link terms and concept map relationships. Concept mapping was reported to be a new concept by 87.5% of the treatment group.

Interview and questionnaire data indicate that computer instruction is viewed positively by students as a way to learn strategies to read difficult material. Indications were that 1) the programs were user-friendly, 2) the strategies were new and useful, 3) the ability to understand text material had improved, and 4) study strategies transferred to use with new textbook chapters.

At a time when many students are enrolling in postsecondary

institutions without the necessary skills to meet required study and reading demands, the computer can be a useful tool to teach effective strategies. The Learning Skills Center is presently developing similar software for psychology texts that will be field tested in the spring of 1988.

For information on how to obtain Using Your Biology Textbook Effectively, the software discussed in this paper, contact:

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Other software developed at the Indiana University Learning Skills Center includes: Using Your Psychology Textbook Effectively, Textbook Marking, Testtaking, and Time Management.

Table I.

Mean Score Differences
of Treatment and Control Subjects
on Embryonic and Blood Chapter Examinations

	Treatment n=25	Control n=25
Embryonic Chapter Exam	79.86	61.92*
Blood Chapter Exam	79.59	63.86*

* Differences significant at the $p < .001$ level

Table II.

Mean Sub-Scale Score Differences
of Treatment and Control Subjects
on Embryonic and Blood Chapter Examinations

	Treatment n=25	Control n=25	Sig Level
Embryonic Exam			
Identifying Key Concepts	18.6	15.2 (20 possible)	.001
Linking Key Terms	17.3	15.3 (20 possible)	.05
Mapping Relationships	44.0	31.5 (60 possible)	.001
Blood Parts Exam			
Identifying Key Concepts	18.4	16.8 (20 possible)	N.S.
Linking Key Terms	18.8	13.8 (20 possible)	.001
Mapping Relationships	42.1	33.2 (60 possible)	.01

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